$K\bar{K}$ THRESHOLD PHENOMENA, $f_0 - a_0$ INTERFERENCE AND KAONIUM PRODUCTION

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We develop a new formalism to study $K\bar{K}$ threshold phenomena with resonances f_0, a_0 and K^+K^- atom (kaonium) included. The approach provides two possible scenarios for $f_0 - a_0$ mixing. Drastic interference patterns can be observed in K^+K^-electroproduction at CEBAF, $pd \to {}^3HeX$ reaction, and $N\bar{N}$ annihilation.

It is well known that there is an interesting sometimes controversial physics bearing upon the $K\bar{K}$ threshold phenomena and the nature of f_0, and a_0 resonances. We try to get a different handle of these issues by constructing an effective Hamiltonian which describes $\bar{K}K$ threshold phenomena, f_0 and a_0 resonances, and kaonium [1,2].

Consider reaction of the type $a + b \to X + M \to \pi^+\pi^- + M$ with invariant mass of X being in the vicinity of the $K\bar{K}$ threshold(s). This might be, e.g., $pd \to {}^3He\pi^+\pi^-$, or $\bar{p}p \to \pi^+\pi^-\eta$, or electroproduction reaction. Since f_0 and a_0 mesons play an important role in $K\bar{K}$ threshold region, we write the amplitude in the following form

$$T =< \hat{V}|\hat{G}|\hat{A} > +T^0, \tag{1}$$

where T^0 is the background (not via f_0) $\pi\pi$ production amplitude,

$$\hat{V} = (V_f, V_a), \hat{A} = \begin{pmatrix} A_f \\ A_a \end{pmatrix}, \hat{G} = \begin{pmatrix} G_{ff} & G_{fa} \\ G_{af} & G_{aa} \end{pmatrix} = (m_X - \hat{H} - \Delta\hat{H})^{-1}. \tag{2}$$

Here A_f and A_a are the f_0, a_0 production amplitudes, the propagator G includes their mixing (see below), V_f and V_a couple f_0 and a_0 to other states (note that $a_0 \to \pi\pi$ is forbidden). Finally

$$\hat{H} = \begin{pmatrix} E_f^{(0)} & 0 \\ 0 & E_a^{(0)} \end{pmatrix}, \Delta\hat{H} = \sum_\alpha \hat{V}^+ \frac{|\alpha >< \alpha|}{m_X - m_\alpha + i0}\hat{V}, \tag{3}$$

where $|\alpha >$ indicates any of the states to which f_0 and a_0 are coupled.

Now we are furnished to provide two possible $f_0 - a_0$ mixing scenarios. One of them has its origin in the $K^0\bar{K}^0$ and K^+K^- threshold splitting of 8 MeV. Taking $\Delta\hat{H}$ as a sum of two

terms corresponding to K^+K^- and $K^0\bar{K}^0$ channels we get

$$\hat{H}+\Delta\hat{H}=\left(\begin{array}{ll} E_f-i\frac{\Gamma_f}{2} & 0 \\ 0 & E_a-i\frac{\Gamma_a}{2}\end{array}\right)+$$

$$+D\left(\begin{array}{ll} 1 & \zeta \\ \bar{\zeta} & |\zeta|^2\end{array}\right)(-i)\sqrt{\frac{m_X-2m_{K^+}}{m_K}+i0}\;+$$

$$+\,D\left(\begin{array}{ll} 1 & -\zeta \\ -\bar{\zeta} & |\zeta|^2\end{array}\right)(-i)\sqrt{\frac{m_X-2m_{K^0}}{m_K}+i0}, \tag{4}$$

$$D=\frac{m_K^2}{4\pi}|<K^+K^-|\hat{V}|f>|^2,\quad \zeta=\frac{<K^+K^-|\hat{V}|a>}{<K^+K^-|\hat{V}|f>}. \tag{5}$$

Second mixing scenario is due to kaonium production. Kaonium with its Bohr radius of 109.6 fm and binding energy of 6.57 keV is formed by electromagnetic interaction and its wave function has two isospin components $I=0,1$ thus providing f_0-a_0 mixing. As shown in [1,2] mixing parameter depends on whether these mesons are $K\bar{K}$ molecules or genuine quark states.

The two mechanisms of mixing have very different energy scales – of few MeV and few keV correspondingly. Typical plots are shown in Figs. 1,2.

Figure Captions

Fig. 1. The typical plots of the matrix element squared for f_0-a_0 mixing due to $\bar{K}K$ mass splitting.

Fig.2. Same as in Fig. 1. with mixing due to kaonium.

References

[1] B.Kerbikov, Z.Phys. **353**, 113, 1995.

[2] S.V.Bashinsky and B.Kerbikov, Preprint DAPNIA/SPhN 95 35, Saclay 1995, to appear in Yad. Fiz. 1996.